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AN OLIGOPOLISTIC MODEL OF A JAPANESE PHARMACEUTICAL COMPANY

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An Oligopolistic Model of a Japanese Pharmaceutical Company*

I. Introduction

Earlier the first author built an oligopolistic model of the American automobile firms[15], demonstrating the possibility of econometric model building at the firm level. In the present paper, on the basis of detailed corporate data, we advance this effort further using more elaborate behavioral hypotheses concerning the behaviors of a firm under an oligopolistic situation. Furthermore, we will experiment with elaborate estimation procedures.

The model attempts to analyze the mechanism of market share, advertising and sales promotion, and price determination as well as other activity aspects of the Eisai Company within the framework of the Japanese pharmaceutical industry. The model may give clues to the reasons and processes of the growth of the firm.

Section II presents the model, and Section III discusses the behavioral hypothesis and estimated result of each behavioral equation in the model, and Section IV gives various forecast results under different sets of assumptions.

II. The Estimated Model

Using semi-annual data for ten years between October 1959 and March 1969, the behavioral equations are estimated by such methods as two-stage least squares(2SLS), Marquart's nonlinear least squares(NLIS) of [10], the nonlinear two-stage least squares(NL2SLS) given in [14], the scanning method(SCAN) of [2], and the modified Sargan's two-stage

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least squares(MS2SLS) given in [1]. $\bar{R}^2$ denotes the coefficient of determination adjusted for degrees of freedom, and DW indicates the Durbin-Watson test statistic. The figure right below a coefficient is the estimated standard error of the coefficient.

The List of Variables

The variables are given in alphabetical order and an endogenous variable in the system is indicated by an asterisk on the upper left hand corner.

$^*AE_t$ = sales and advertising expenditure of Eisai at time t, millions of current yen

$^*AE_{i,t}$ = sales and advertising expenditure for the i-th product of Eisai at time t, millions of current yen, i=NS, CR, D, V, NU, and EP

AO_t = sales and advertising expenditure of companies except Eisai at time t, millions of current yen

a_{it} = the proportion of sales and advertising expenditure allocated to the i-th product of Eisai at time t, i=NS, CR, D, V, NU, and EP

$^*BLD_t$ = depreciation allowances of buildings at time t, millions of current yen

$^*CP_t$ = production costs of Eisai at time t, millions of current yen

$^*DISC_t$ = sales discounts at time t, millions of current yen

DET_t = outstanding debts at time t, millions of current yen

DIV_t = dividend payments at time t, millions of current yen

$\bar{E}_{BC,t}$ = Eisai's sales of chemotherapeutics and anti-biotics at time t, millions of current yen

$^*E_{CR,t}$ = Eisai's sales of cardiovascular agents and agents affecting respiratory organs at time t, millions of 1965 yen

$^*E_{D,t}$ = Eisai's sales of agents affecting digestive organs and agents for uro-genital and anal organs at time t, millions of 1965 yen

$^*E_{EP,t}$ = Eisai's sales of agents for epidermis at time t, millions of 1965 yen

$^*E_{NS,t}$ = Eisai's sales of agents affecting nerve system and sensory organs at time t, millions of 1965 yen

$^*E_{NU,t}$ = Eisai's sales of nutrients, tonics and alternatives at time t, millions of 1965 yen

$\bar{E}_{o,t}$ = Eisai's sales of other products at time t, millions of current yen

$*E_{V,t}$ = Eisai's sales of vitamin preparations at time t, millions of 1965 yen

$*EX_t$ = real net sales of Eisai at time t, millions of 1965 yen

$EXRM_t$ = renumerations to the executives at time t, millions of current yen

FRP_t = the proportion of female to the total production workers at time t

FRS_t = the proportion of female to the total sales employees at time t

$*GIBL_t$ = gross investment in buildings at time t, millions of 1965 yen

$*GS_t$ = gross sales at time t, millions of current yen

$*ID_t$ = payments of interests on debts at time t, millions of current yen

$\Delta INCOM_t$ = a change in inventories of office and distribution materials at time t, millions of current yen

$\Delta INPR_t$ = a change in inventoreis of production materials at time t, millions of current yen

$*L_{p,t}$ = the number of production workers at time t

$*L_{RD,t}$ = the number of research and development employees at time t

$*L_{s,t}$ = the number of sales employees at time t

$*MED_t$ = depreciation allowances of machinery and equipment at time t, millions of current yen

N_t = total population at time t, thousands of persons

$*NIBL_t$ = net investment in buildings at time t, millions of 1965 yen

$*NIME_t$ = net investment in machinery and equipment at time t, millions of 1965 yen

$*NKBL_t$ = net capital stock of buildings at time t, millions of 1965 yen

$*NKME_t$ = net capital stock of machinery and equipment at time t, millions of 1965 yen

$*OAC_t$ = other administrative costs at time t, millions of current yen

$*OPRC_t$ = other production costs at time t, millions of current yen

$*OREV_t$ = other revenues at time t, millions of current yen

$OTEX_t$ = other miscellaneous expenses not related to sales activities at time t, millions of current yen

P_t = industrial price index of all pharmaceutical products at time t, 1965=100.0

$*PE_t$ = the general price index of Eisai products at time t, 1965=100.0

$*PE_{it}$ = the price index of Eisai's i-th product at time t, 1965=100.0, i=NS, CR, D, V, NU, and EP

$P_{k,t}$ = the price index of capital goods at time t, 1965=100.0

$P_{M,t}$ = the price index of raw materials at time t, 1965=100.0

$P_{NU,t}$ = industrial price index of nutrients, tonics, and alternatives at time t, 1965=100.0

$^*PRO_t$ = Eisai's sales promotion expenditure excluding wages, salaries and bonuses of the sales employees, at time t, millions of current yen

$\phi_{i,t}$ = the coefficient to determine the price index of the i-th product of Eisai at time t

$^*\Pi_{A,t}$ = profits after taxes at time t,millions of current yen

$^*\Pi_{B,t}$ = profits before national corporate income taxes at time t, millions of current yen

$^*\Pi_{G,t}$ = sales profits and other revenues at time t, millions of current yen

$^*\Pi_{GS,t}$ = gross sales profits at time t, millions of current yen

$^*\Pi_{NS,t}$ = profits out of net sales at time t, millions of current yen

Q_1 = dummy; one for the first half of the year(April-September) and zero for the second half of the year(October-March)

$^*RD_t$ = research and development expenditure at time t, millions of current yen

$^*RE_t$ = retained earings at time t, millions of current yen

$^*TC_t$ = national corporate income taxes at time t, millions of current yen

$^*TL_t$ = prefecture and local taxes at time t, millions of current yen

$^*V_t$ = net sales of Eisai at time t, millions of current yen

$w_{o,t}$ = the wage, salary and bonus rate of the employees of other companies at time t, millions of current yen

$^*w_{p,t}$ = the wage, salary and bonus rate of the sales employees of Eisai at time t, millions of current yen

$^*w_{RD,t}$ = the wage, salary and bonus rate of research and development employees at time t, millions of current yen

$^*w_{s,t}$ = the wage, salary and bonus rate of the sales employees at time t, millions of current yen

$^*x_{BC,t}$ = per capita industrial production of antibiotics and chemotherapeutics at time t, thousands of 1965 yen

$^*x_{CR,t}$ = per capita industrial production of cardiovascular agents and agents affecting respiratory organs at time t, thousands of 1965 yen

$^*x_{D,t}$ = per capita industrial production of agents affecting digestive organs and agents for uro-genital and anal organs at time t, thousands of 1965 yen

$*x_{EP,t}$ = per capita industrial production of agents for epidermis at time t, thousands of 1965 yen

$*x_{NS,t}$ = per capita industrial production of agents affecting nerve system and sensory organs at time t, thousands of 1965 yen

$*x_{NU,t}$ = per capita industrial production of nutrients, tonics, and alternatives at time t, thousands of 1965 yen

$*x_{o,t}$ = per capita industrial production of other pharmaceutical products at time t, thousands of 1965 yen

$*X_{i,t}$ = industrial production of the i-th product at time t, millions of 1965 yen, i=NS,CR,D,V,NU,EP,BC, and o

$y_{D,t}$ = per capita real personal consumption and medicare expenditure at time t, weighted by the age distribution and incidence of suffering from illness affecting digestive, uro-genital and anal organs, millions of 1965 yen

$y_{CR,t}$ = per capita real personal consumption and medicare expenditure at time t, weighted by the age distribution and incidence of suffering from illness affecting cardiovascular and respiratory organs, millions of 1965 yen

$y_{NS,t}$ = per capita real personal consumption and medicare expenditure at time t, weighted by the age distribution and incidence of suffering from illness affecting nerve system and sensory organs, millions of 1965 yen

$y_{T,t}$ = per capita real personal consumption and medicare expenditure at time t, weighted by the age distribution and incidence of suffering from all types of illness, millions of 1965 yen

Industrial demand

$$(2\text{-}1)\quad \ln x_{NS,t} \underset{(.0440)}{-.7229} \ln x_{NS,t-1} = \underset{(.1074)}{2.3692}\Big[\frac{1}{G}\sum_{k=1}^{15} k^{s-1}e^{-k}$$

$$(\ln y_{NS,t-k+1} - .7229 \ln y_{NS,t-k})\Big]$$

$$\underset{(.0656)}{-.1061}[\underset{(.0112)}{(.8204)^{t}} - .7229(.8204)^{t-1}]$$

$$+ \underset{(.0551)}{.1507}\, Q_1 - \underset{(.0206)}{.1601}$$

$\bar{R}^2 = .985$

$s = \underset{(.1074)}{2.2529}$

DW=1.902

NLLS

$$G = \sum_{k=1}^{30} k^{s-1}e^{-k}$$

$$(2\text{-}2)\quad \ln x_{CR,t} = \underset{(2.7126)}{3.6118}\Big[\frac{1}{G}\sum_{k=1}^{15} k^{s-1}e^{-k}\ln y_{CR,t-k+1}\Big]$$

$$+ \underset{(3.1870)}{.7698}[\underset{(.3477)}{.9083}]^{t} + \underset{(.0312)}{.0412}\, Q_1 - \underset{(.7265)}{.6368}$$

$\bar{R}^2 = .990$

DW=1.909

NLLS

$s = \underset{(1.6892)}{2.9427}$

$$(2\text{-}3)\quad \ln x_{D,t} = \underset{(.3566)}{1.8757}\Big[\frac{1}{G}\sum_{k=1}^{15} k^{s-1}e^{-k}\ln y_{D,t-k+1}\Big]$$

$$- \underset{(.5794)}{.0757}[\underset{(.5608)}{.9058}]^{t} - \underset{(.0010)}{1.4901}$$

$\bar{R}^2 = .974$

DW=1.505

NLLS

$s = \underset{(.7825)}{1.7519}$

(2-4) $$\ln x_{V,t} - \underset{(.0607)}{.8589} \ln x_{V,t-1} = \underset{(.1241)}{1.4539}\left[\frac{1}{G}\sum_{k=1}^{15} k^{s-1}e^{-k}(\ln y_{T,t-k+1} - .8589 \ln y_{T,t-k})\right] - \underset{(.1092)}{.0388}\left[(\underset{(.0548)}{.9121})^{t} - .8589(.9121)^{t-1}\right] - \underset{(.0629)}{.0842}$$

$\bar{R}^2 = .959$

DW=2.018

NLLS

$s = \underset{(.1241)}{2.1950}$

(2-5) $$\ln x_{NU,t} = \underset{(.6175)}{2.0868}\left[\frac{1}{G}\sum_{k=1}^{15} k^{s-1}e^{-k}\ln y_{T,t-k+1}\right] - \underset{(.2190)}{.4218}[\underset{(.3717)}{.8328}]^{t} - \underset{(.5354)}{1.8774}\frac{P_{NU,t}}{P_t} + \underset{(.4898)}{1.1669}$$

$\bar{R}^2 = .994$

DW=1.464

NLLS

$s = \underset{(2.2690)}{2.4999}$

(2-6) $$\ln x_{EP,t} - \underset{(.0538)}{.8199} \ln x_{EP,t-1} = \underset{(.0605)}{.0617}\left[\frac{1}{G}\sum_{k=1}^{15} k^{s-1}e^{-k}(\ln y_{T,t-k+1} - .8199 \ln y_{T,t-k})\right] - \underset{(.0522)}{.0590}\left[(\underset{(.0602)}{.9634})^{t} - .8199(.9634)^{t-1}\right] - \underset{(.0561)}{.3140}$$

$\bar{R}^2 = .854$

DW=2.251

NLLS

$s = \underset{(.0562)}{2.5151}$

(2-7) $$\ln x_{BC,t} = \underset{(1.3441)}{2.8320}\left[\frac{1}{G}\sum_{k=1}^{15} k^{s-1}e^{-k}\ln y_{T,t-k+1}\right] + \underset{(1.5039)}{.5240}[\underset{(.3124)}{.8929}]^{t} - \underset{(.5317)}{.5976}$$

$\bar{R}^2 = .989$

DW=1.477

NLLS

$s = \underset{(1.6369)}{2.4926}$

$$(2\text{-}8)\quad \ln x_{o,t} = \underset{(1.7493)}{1.4374}\left[\frac{1}{G}\sum_{k=1}^{15} k^{s-1}e^{-k}\ln y_{T,t-k+1}\right]$$

$$+ \underset{(.1316)}{.2376}\,\underset{(1.1456)}{[.9380]^{t}} - \underset{(.0004)}{1.6453}$$

$\bar{R}^2 = .907$

DW=1.380

NLLS

$s = \underset{(1.5823)}{4.4080}$

$$(2\text{-}9)\quad X_{i,t} = x_{i,t}N_t \qquad i=NS, CR, D, V, NU, EP, BC, \text{ and } o$$

Market shares for Eisai products

$$(2\text{-}10)\quad E_{NS} + \underset{(.7676)}{.4922}E_{NS,t-1} = \underset{(.1065)}{.4956}\left[\frac{1}{G}\sum_{k=1}^{6} k^{s-1}e^{-k}\left(\frac{AE_{t-k+1}}{AO_{t-k+1}}X_{NS,t-k+1}\right.\right.$$

$$\left.\left. + .4922\,\frac{AE_{t-k}}{AO_{t-k}}X_{NS,t-k}\right)\right] + \underset{(203.6333)}{710.8837}$$

$\bar{R}^2 = .957$

DW=2.102

NL2SLS

$s = \underset{(1.5230)}{2.4828}$

$$(2\text{-}11)\quad E_{CR,t} - \underset{(.2909)}{.8626}\,E_{CR,t-1} = \underset{(.3158)}{.4513}\left[\frac{1}{G}\sum_{k=1}^{6} k^{s-1}e^{-k}\left(\frac{AE_{t-k+1}}{AO_{t-k+1}}X_{CR,t-k+1}\right.\right.$$

$$\left.\left. - .8626\,\frac{AE_{t-k}}{AO_{t-k}}X_{CR,t-k}\right)\right] + \underset{(199.0127)}{197.8200}$$

$\bar{R}^2 = .837$

DW=1.212

NL2SLS

$s = \underset{(1.1956)}{2.6441}$

$$(2\text{-}12)\quad E_{D,t} - \underset{(.2352)}{.8001}\,E_{D,t-1} = \underset{(.9891)}{1.5712}\left[\frac{1}{G}\sum_{k=1}^{6} k^{s-1}e^{-k}\left(\frac{AE_{D,t-k+1}}{AO_{t-k+1}}X_{D,t-k+1}\right.\right.$$

$$\left.\left. - .8001\frac{AE_{D,t-k}}{AO_{t-k}}X_{D,t-k}\right)\right] + \underset{(233.1674)}{283.3247}$$

$\bar{R}^2 = .825$

DW=1.446

NL2SLS

$s = \underset{(7.6846)}{.1311}$

$$\text{(2-13)}\quad \underset{}{E_{V,t}} \underset{(.5706)}{-.7626} E_{V,t-1} = \underset{(.2490)}{.7024}\left[\frac{1}{G}\sum_{k=1}^{6} k^{s-1} e^{-k}\left(\frac{AE_{t-k+1}}{AO_{t-k+1}} X_{V,t-k+1} - .7626\frac{AE_{t-k}}{AO_{t-k}} X_{V,t-k}\right)\right] \underset{(97.6893)}{-148.8785}$$

$\bar{R}^2 = .901$

$s = \underset{(1.5934)}{1.7729}$

DW=1.371

NL2SLS

$$\text{(2-14)}\quad E_{NU,t} = \underset{(.0518)}{.0508}\frac{1}{G}\sum_{k=1}^{6} k^{s-1} e^{-k} \frac{AE_{t-k+1}}{AO_{t-k+1}} X_{NU,t-k+1} + \underset{(.5442)}{3.8054}\frac{1}{G}\sum_{k=1}^{6} k^{s-1} e^{-k} \frac{AE_{NU,t-k+1}}{AO_{t-k+1}} X_{NU,t-k+1} + \underset{(82.5539)}{111.7327}$$

$\bar{R}^2 = .983$

$s = \underset{(1.1131)}{1.5139}$

DW= 2.284

NL2SLS

$$\text{(2-15)}\quad E_{EP,t} \underset{(7.9955)}{+ .5297} E_{EP,t-1} = \underset{(1.9018)}{6.4369}\left[\frac{1}{G}\sum_{k=1}^{6} k^{s-1} e^{-k}\left(\frac{AE_{EP,t-k+1}}{AO_{t-k+1}} X_{EP,t-k+1} + .5297\frac{AE_{EP,t-k}}{AO_{t-k}} X_{EP,t-k}\right)\right] \underset{(41.4939)}{+ 40.8624}$$

$\bar{R}^2 = .687$

DW=2.392

NL2SLS

<u>Advertising and sales promotion</u>

$$\text{(2-16)}\quad PRO_t \underset{(.4295)}{- .7682} PRO_{t-1} = \underset{(.0693)}{.2842}\left[\frac{1}{G}\sum_{k=1}^{6} k^{s-1} e^{-k}\left(V_{t-k+1} - .7682\, V_{t-k}\right)\right] \underset{(16.0782)}{+ 73.7666}$$

$\bar{R}^2 = .991$

$s = \underset{(4.3484)}{.5004}$

DW=2.248

NL2SLS

(2-17) $AE_t = PRO_t + w_{s,t} L_{s,t}$

(2-18) $AE_{i,t} = a_{it} AE_t$ i=NS,CR,D,V,NU and EP

(2-19) $DISC_t - .7692\ DISC_{t-1} = \underset{(.0602)}{.1311}[GS_t - .7692\ GS_{t-1}]$

$+ \underset{(159.9848)}{93.0903}$

$\bar{R}^2 = .824$

DW=1.618

MS2SLS

Price and wage determination

(2-20) $PE_t - .5254 PE_{t-1} = \underset{(11.4112)}{38.8120}\left[\frac{V_t - \Pi NS_t}{EX_t} - .5254\ \frac{V_{t-1} - \Pi NS_{t-1}}{EX_{t-1}}\right]$

$+ \underset{(4.3762)}{31.6575}$

$\bar{R}^2 = .649$

DW=1.021

MS2SLS

(2-21) $PE_{i,t} = \phi_{i,t}\ PE_t$, i=NS,CR,D,V,NU and EP

(2-22) $w_{s,t} - .5753\ w_{s,t-1} = \underset{(.1647)}{1.4136}[w_{o,t} - .5753\ w_{o,t-1}]$

$- \underset{(.7402)}{1.4431}[FRS_t - .5753\ FRS_{t-1}] + \underset{(.0834)}{.1128}$

$\bar{R}^2 = .966$

DW=1.940

SCAN

(2-23) $w_{p,t} = \underset{(.2137)}{.8118}\ w_{s,t} - \underset{(.5031)}{.3012}\ FRP_t + \underset{(.3140)}{.2606}$

$\bar{R}^2 = .921$

DW=1.916

2SLS

(2-24) $w_{RD,t} = \underset{(.0722)}{.7005}\, w_{s,t} + \underset{(.0241)}{.1171}$

$\bar{R}^2 = .870$
DW=1.656
2SLS

Labor demand

(2-25) $L_{s,t} - .5897\, L_{s,t-1} = \underset{(.0119)}{.0397}[EX_t - .5897 EX_{t-1}] + \underset{(41.8835)}{210.9635}$

$\bar{R}^2 = .848$
DW=2.307
MS2SLS

(2-26) $L_{p,t} = \underset{(.0130)}{.0339} EX_t - \underset{(482.8105)}{311.1904} \frac{w_{p,t-1}}{P_{k,t-1}} + \underset{(88.8703)}{463.2034}$

$\bar{R}^2 = .723$
DW=1.484
2SLS

(2-27) $L_{RD,t} = \underset{(.0017)}{.0103} EX_t + \underset{(13.4723)}{111.5623}$

$\bar{R}^2 = .725$
DW=1.695
2SLS

Investment functions

(2-28) $NIME_t = \underset{(.0352)}{.0553}[\frac{1}{G} \sum_{k=1}^{6} k^{s-1} e^{-k} (EX_{t-k+1} - EX_{t-k})]$

$- \underset{(.0542)}{.0545}\, L_{p,t-1} + \underset{(19.4635)}{44.2853}$

$s = \underset{(1.2252)}{2.4332}$

$\bar{R}^2 = .514$
DW=1.432
NL2SLS

(2-29) $GIBL_t - \underset{(.1176)}{.6453}\, GIBL_{t-1} = \underset{(.2066)}{.0297}\{\frac{1}{G} \sum_{k=1}^{6} k^{s-1} e^{-k} [(EX_{t-k+1}$

$- EX_{t-k}) - .6453(EX_{t-k} - EX_{t-k-1})]\}$

$+ \underset{(.3254)}{.0616}[NKBL_{t-1} - .6453 NKBL_{t-2}] + \underset{(30.4011)}{71.2103}$

$\bar{R}^2 = .538$

$$s = \underset{(1.5205)}{2.6500}$$

DW=1.965
NL2SLS

(2-30) $NIBL_t = GIBL_t - BLD_t$

(2-31) $NKME_t = NIME_t + NKME_{t-1}$

(2-32) $NKBL_t = NIBL_t + NKBL_{t-1}$

Research and development expenditure

(2-33) $RD_t - .7436RD_{t-1} = \underset{(.0154)}{.0761}[V_t - .7436V_{t-1}] \underset{(36.7710)}{-31.8356}$

$\bar{R}^2 = .980$
DW=1.498
MS2SLS

Raw materials

(2-34) $RM_t = \underset{(.0071)}{.2155} EX_t + \underset{(52.9826)}{179.2333}$

$\bar{R}^2 = .985$
DW=2.046
2SLS

Other production costs

(2-35) $OPRC_t - .5897\ OPRC_{t-1} = \underset{(.0063)}{.0270}[V_t - .5897V_{t-1}]$

$$\underset{(19.4592)}{+11.1628}$$

$\bar{R}^2 = .951$
DW=2.225
2SLS

Other administrative costs

(2-36) $OAC_t = \underset{(.0035)}{.0516} V_t - \underset{(25.2659)}{20.0484}$

$\bar{R}^2 = .940$
DW=2.225
2SLS

Interests on debts

$$(2\text{-}37)\quad ID_t - .4872\, ID_{t-1} = \underset{(.0032)}{.0413}[DET_t - .4872\, DET_{t-1}] + \underset{(9.5884)}{42.8960}$$

$\bar{R}^2 = .924$
DW=1.454
SCAN

Depreciation allowances

$$(2\text{-}38)\quad MED_t = \underset{(.0231)}{.1753} NKME_{t-1} - \underset{(13.8102)}{11.2101}$$

$\bar{R}^2 = .802$
DW=1.474
OLS

$$(2\text{-}39)\quad BLD_t = \underset{(.0028)}{.0597}\, NKBL_{t-1} - \underset{(3.2204)}{10.6404}$$

$\bar{R}^2 = .970$
DW=1.614
OLS

Other revenues

$$(2\text{-}40)\quad OREV_t = \underset{(.0015)}{.0076}\, V_t + \underset{(11.1441)}{26.8614}$$

$\bar{R}^2 = .627$
DW=1.545
2SLS

Taxes

$$(2\text{-}41)\quad TL_t - .3077\, TL_{t-1} = \underset{(.0146)}{.1164}[\Pi_{B,t-1} - .3077\Pi_{B,t-2}] + \underset{(10.5720)}{13.9347}$$

$\bar{R}^2 = .818$
DW=1.386
SCAN

$$(2\text{-}42)\quad TC_t = \underset{(.0099)}{.3638}\Pi_{B,t} + \underset{(11.1187)}{48.9143}$$

$\bar{R}^2 = .990$
DW=1.496
2SLS

Identities

$$(2\text{-}43)\quad GS_t = PE_{NS,t}E_{NS,t} + PE_{CR,t}E_{CR,t} + PE_{D,t}E_{D,t} + PE_{V,t}E_{V,t}$$

$$PE_{NU,t}E_{NU,t} + PE_{EP,t}E_{EP,t} + \overline{E}_{BC,t} + \overline{E}_{o,t}$$

$$(2\text{-}44)\quad V_t = GS_t - DISC_t$$

$$(2\text{-}45)\quad EX_t = \frac{V_t}{PE_t}$$

$$(2\text{-}46)\quad CP_t = w_{p,t}L_{p,t} + OPRC_t + P_{M,t}RM_t - \Delta INPR_t$$

$$(2\text{-}47)\quad \Pi_{GS,t} = V_t - CP_t - \Delta INCOM_t$$

$$(2\text{-}48)\quad \Pi_{NS,t} = \Pi_{GS,t} - (AE_t + w_{RD,t}L_{RD,t} + RD_t + TL_t + P_{k,t}MED_t$$

$$+ P_{k,t}BLD_t)$$

$$(2\text{-}49)\quad \Pi_{G,t} = \Pi_{NS,t} + OREV_t$$

$$(2\text{-}50)\quad \Pi_{B,t} = \Pi_{G,t} - ID_t - OTEX_t$$

$$(2\text{-}51)\quad \Pi_{A,t} = \Pi_{B,t} - TC_t$$

$$(2\text{-}52)\quad RE_t = \Pi_{A,t} - DIV_t - EXRM_t$$

III. Behavioral Hypotheses and Estimated Results

The Japanese pharmaceutical industry has grown in terms of output 4.8 time in ten years between 1959 and 1968. Approximately, 60 percent of the industrial output is produced by eleven companies, although the number of firms in the industry is said to be around 2,300. The combined market share of these eleven companies in ethical drugs is estimated to reach 80 percent. Table 1 below presents the net sales of the top nine companies during the latter half of 1968 fiscal period. Table 1 indicates three groups of companies among the top nine firms: the first group is Takeda alone whose sales are more than three times as large as those of Sankyo, the second largest. The second group consists of three companies whose sales range between 20 and 24 billion yen, and the third group with five companies whose sales are 11 to 14.5 billion yen. The Eisai Company whose model we are building belongs to the third group. However, the company is growing fast at the rate of 111 percent over four years between 1964 and 1968.

Table 1

Net Sales and Growth Rates of Top Nine Companies

Company	Net Sales (100 million yen)	Growth Rate (1968/1964)
Takeda	780	45.5%
Sankyo	240	43.0
Shionogi	220	33.5
Tanabe	206	29.5
Fujisawa	145	75.1
Eisai	130	111.0
Yamanouchi	127	81.0
Banyu	120	119.3
Daiichi	112	36.9

Source: Nihon Keizai Shinbun, June 20, 1969

In the following subsections we explain the hypotheses behind the behavioral equations and evaluate the estimated results. The hypotheses are based on the institutional characteristics of the industry and of the Japanese economy.

3.1 Consumer Demand for Pharmaceutical Products: The demand for pharmaceutical products is based on two propositions: strongly separable utility and the Gompertz curve. Many of the pharmaceutical products are used for a particular need of a consumer and often he has little choice in deciding whether he sould buy a pharmaceutical product or other commodity,say, steak, to satisfy his utility. In this regard the consumer may well possess strongly separable utility function as far as his demand for the pharmaceutical products is concerned.

Suppose that the consumer is concerned with n commodities, $x_1,\ldots,x_n$. These n commodities may be partitioned into a class of mutually exclusive and exhaustive subsets, $\{N_1,\ldots,N_s\}$. Then a commodity bundle, $X=(x_1,\ldots,x_n)$ may be correspondingly partitioned into $(\underset{\sim}{X}_1,\ldots,\underset{\sim}{X}_s)$, where, for each s, the subvector $\underset{\sim}{X}_s$ is composed of x_i, $i\varepsilon N_s$. Then, a strongly separable utility function is given by

$$(3\text{-}1) \qquad U(\underset{\sim}{X})=U[V_1(\underset{\sim}{X}_1)+\ldots V_s(\underset{\sim}{X}_s)]$$

where $V_s(\underset{\sim}{X}_s)$ is a function of subvector $\underset{\sim}{X}_s$. If we postulate the strongly separable utility function (3-1) and if the demand function is represented by a linear function, then the following proposition may be made:

Proposition 1. If the utility function is strongly separable and if the demand function is linear, then, the following grouping of prices in the demand function is possible:

$$(3\text{-}2) \qquad x_i = \beta_{i1} + \beta_{i2}(P_i/P_{N_s}) + \gamma_i(Y/P) \qquad \text{for } i \varepsilon N_s,$$

where $P_{N_s} = \sum_{g \varepsilon N_s} \alpha_g P_g$, and $P = \sum_{\tau=1}^{n} w_\tau P_\tau$, i.e., P_{N_s} is the weighted price index of commodities in N_s, whereas P is the price index of all commodities, and Y is money income.(1)

Given equation (3-2), we may aggregate over all the commodities in N_s (say, agents affecting nerve system and sensory organs) to derive a demand function for the group of commodities in N_s, which is denoted by x_{N_s}. In this aggregation

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(1) as shown in [12,p.487] it is easy to prove that in the case of strong separability we will have a relationship

$$(1) \frac{\partial x_i}{\partial P_k} \Big/ \frac{\partial x_j}{\partial P_k} = \frac{\partial x_i}{\partial Y} \Big/ \frac{\partial x_j}{\partial Y}, \text{ for all } i\varepsilon N_s,\ j\varepsilon N_t, \text{ and}$$

and $k \notin N_s \cup N_t$ $(s \neq t)$. For $i\varepsilon N_s$ we obtain from equation (3-2)

$$\frac{\partial x_i}{\partial P_k} = -\gamma_i Y \frac{w_k}{P^2} \quad \text{for } k \notin N_s \cup N_t, \text{ and } \quad \frac{\partial x_i}{\partial Y} = \gamma_i \frac{1}{P} \text{ ; hence}$$

we have

$$(2) \quad \frac{\partial x_i}{\partial P_k} = - \frac{w_k Y}{P} \frac{\partial x_i}{\partial Y}.$$

Similarly for $j\varepsilon N_t$ $(s \neq t)$, we have

$$(3) \quad \frac{\partial x_j}{\partial P_k} = - \frac{w_k Y}{P} \frac{\partial x_j}{\partial Y}.$$

Taking the ratio of (2) to (3) we obtain (1) which is a necessary condition for strong separability.

process, the relative price term, P_i/P_{N_s}, may tend to be cancelled to arrive at

$$(3\text{-}3) \qquad x_{N_s} = \alpha_o + \alpha_1 \frac{Y}{P} \text{ .(2)}$$

We use equation (3-3) for our demand functions, to show whether this representation is empirically reasonable or not, we test it against an equation involving a relative price term.

As we noted earlier, the Japanese pharmaceutical industry is characterized by the fast growth. When the industry is growing fast, the major concern is when the pace of fast growth will slow down. A mathematical function to express the life cycle pattern of such growth is some form of logistic curve. The Gompertz curve has an advantage over the usual logistic curve because the former is not symmetric around the point of inflection.

Using the Gompertz curve, we formulate the demand functions as follows:

$$(3\text{-}4) \qquad x_{it} = x^*_{it}\, a_i^{b_i^t}\, u_{it} , \qquad 0 < b_i < 1$$

$$(3\text{-}5) \qquad x^*_{it} = A_i \prod_{j=0}^{m} y_{i,t-j}^{\alpha_i \lambda_i (j)}$$

where x_{it} = per capita industrial demand for the i-th pharmaceutical product at time t

$y_{i,t}$ = per capita real consumer expenditure and medicare expenditure at time t, population being weighted by the age distribution and incidence of suffering from the i-th type illness

x^*_{it} = expected per capita industrial demand for the i-th pharmaceutical product at time t

u_{it} = disturbance term

$\{\lambda_i(j)\}_{j=0}^{m}$ = distributed lag coefficients.

Substituting equation (3-5) into (3-4), and taking logarithm, we obtain,

$$(3\text{-}6) \qquad \ln x_{it} = \ln A_i + \alpha_i \sum_{j=0}^{m} \lambda_i(j) \ln y_{i,t-j} + b_i^t \ln a_i + \ln u_{it}$$

which is in the same form as equation (3-3). The distributed lag coefficients, $\{\lambda_i(j)\}_{j=0}^{m}$ are represented by the gamma distributed lags given in [13]. We have used the gamma lags as hypothesis for possible "explanation" of the data. Since equation (3-6) is nonlinear in parameters, we have used the nonlinear least squares method [10].

The percapita real consumer expenditure and medicare expenditure, $y_{i,t}$, is derived by weighting the population by age group and the incidence of suffering from the i-th type illness per 100,000 persons within the group. This weighting is due to the fact that the incidence of suffering from the i-th type illness across age group is different from that of the j-th type illness. Figures 1-a and 1-b illustrate this point: illness related to respiratory organs is the highest in the 0-4 year old age group, while illness related to nerve and sensory organs is the highest in the age groups of 65 years old and over.

Population, N, is weighted as follows:

$$N_{i,t} = \sum_{j=1}^{s} c_j^i N_{j,t}$$

where $N_{i,t}$ = the weighted population for the i-th type product at time t

c_j^i = the j-th age group's weighting factor for the i-th product

$N_{j,t}$ = the j-th age distribution at time t

---

(2) By suming x_i over all $i \varepsilon N_s$ we obtain

$$(*) \quad \sum_{i \varepsilon N_s} x_i = \sum_{i \varepsilon N_s} \beta_{i1} + \frac{\sum_{i \varepsilon N_s} \beta_{i2} P_i}{P_{N_s}} + (\sum_{i \varepsilon N_s} \gamma_i) \frac{Y}{P},$$

but $P_{N_s} = \sum_{i \varepsilon N_s} \alpha_i P_i$, and if β_{i2} is close to α_i, then, the second term on the right hand side is close to unity, or if $\beta_{i2} \neq \alpha_i$, treating it as a constant may not involve much error. Then, we may rewrite (*) by (3-3).

and the weighting factor c_j^i is given by

$$c_j^i = \frac{\frac{1}{r_j^i}}{\Sigma \left(\frac{1}{r_j^i}\right)}$$

where r_j^i = the incidence of suffering from the i-th type illness per 100,000 persons of the j-th age group.

The percapita consumption and medicare expenditure for the i-th product, $y_{i,t}$, is derived by

$$y_{i,t} = \frac{CE_t}{N_{it}}$$

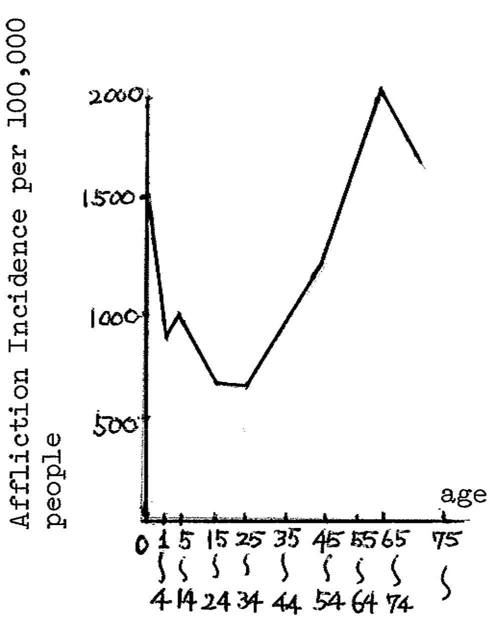
where CE_t = real total consumer expenditure and medicare expenditure at time t

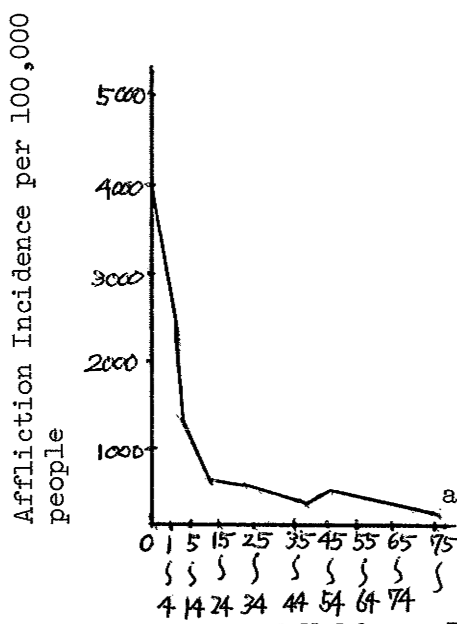
<u>Figure 1-a</u>

Illness related to Nerve and Sensory Organs

<u>Figure 1-b</u>

Illness related to Respiratory Organs





Source: <u>Health Survey</u>, Ministry of Health and Welfare, Tokyo,1966, p.46.

The age groups are broken down into five categories for all types of pharmaceutical products: (i) 0-4 years old, (ii) 5-14 years old, (iii) 15-34 years old, (iv) 35 - 54 years old, (v) 55 years old and above.[3]

The demand equation (3-6) is estimated for the following eight product groups: (i) agents affecting nerve system and sensory organs; (ii) cardiovascular agents and agents affecting respiratory organs; (iii) agents affecting digestive organs and agents for uro-genital and anal organs; (iv) vitamin preparations; (v) nutrients, tonics and alternatives; (vi) agents for epidermis; (vii) chemotherapeutics and antibiotic preparations, and (viii) others.

In the case where the preliminary estimation indicated the existence of the first-order autocorrelation judged by the Durbin-Watson test statistic , equation (3-6) was transformed into

$$(3\text{-}7) \qquad \ln x_{it} - \rho_i \ln x_{i,t-1} = (1 - \rho_i)\ln A_i$$

$$+ \alpha_i \sum_{j=0}^{m} \lambda_i(j)(\ln y_{i,t-j} - \rho_i \ln y_{i,t-j-1})$$

$$+ (b_i^t - {}_i b_i^{t-1})\ln a_i + e_t$$

where $e_t = \ln u_{it} - \rho_i \ln u_{it-1}$, and ρ_i is the coefficient of the first order autocorrelation.

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(3) This break down of ages is based on the table of affliction incidence per 100,000 persons classified according to age, sex, and types of illness which is given in the Ministry of Health and Welfare, Health Survey, 1963, Tokyo, pp.48 - 49.

Equation (3-6) which is based on strong separable utility is tested against the model which included a relative price variable.(4) Except for the nutrients, tonics and alternatives, the relative price variable turned out to be insignificant.

We found that three products, i.e.,agents affecting the nervous system and sensory organs, vitamin preparations and agents for epidermis, are autocorrelated and in these cases equation (3-7) was used for estimation.

Table 2 below presents the lag structures of the demand functions. The lags are similar except for other pharmaceutical products, $x_{o,t}$.

Table 2

Lag Structures of Demand Functions

time	x_{NS}	x_{CR}	x_D	x_V	x_{NU}	x_{EP}	x_{BC}	x_o
0	.3394	.1948	.4597	.3530	.2856	.2802	.2851	.0359
1	.2976	.2755	.2848	.2973	.2951	.2946	.2951	.1401
2	.1819	.2228	.1421	.1776	.1987	.2003	.1988	.2052
3	.0960	.1433	.0649	.0921	.1122	.1139	.1124	.2013
4	.0467	.0813	.0282	.0442	.0576	.0588	.0577	.1584
5	.0216	.0426	.0119	.0202	.0278	.0285	.0279	.1085
6	.0096	.0212	.0049	.0090	.0129	.0132	.0129	.0675
7	.0042	.0101	.0020	.0039	.0058	.0060	.0058	.0215
8	.0018	.0047	.0080	.0016	.0025	.0026	.0025	.0215

Examining the estimated coefficients of per capita consumption and medicare expenditure, y_{it}, we find that consumption elasticities are between 1.44 and 3.6 except for that of agents for epidermis which is 0.0617. This may be a result of a change in the living standard as the Japanese economy has expanded: for example, frost bite used to be a

(4) This test should be regarded as partial and rough rather than as a strict test of hypothesis, for the test of whether a separable utility holds or not depends on the form of demand function as well as on the available data, and the relative prices one uses influence the test. The relative price, P_i/P, used in the test was the price index of the i-th product against the price index of all pharmaceutical products.

common phenomenon during winter, but as diet and heating environment improved it has become rare except in some rural villages.

3.2 The Market Share Determination: Whether a firm tries to expand its market share or not depends upon the firm's behavioral goal. One of the main objectives of the company we are investigating here, i.e., Eisai Company, is sales maximization subject to a minimum required profit. This behavioral goal seems to be prevalent among many Japanese firms of various industries.

If the demand for the industry as a whole is given, then the sales maximization may be interpreted as the maximization of the market share. Among the variables the company more or less controls in order to increase its market share are sales and advertising expenditure, and research and development(R&D) expenditure. The relationship between the latter expenditure and the development of a new product is at present receiving more and more attention and it should be examined carefully. As much as we would like to explore this further, the available data on R&D activities of the firms we investigated are too scanty and rough to enable the analysis of the relationship between new products and R&D expenditure. Consequently, in this study we will focus our attention on the relationship between the market share and sales and advertising expenditure. For this purpose, we formulate a simple hypothesis

$$(3\text{-}8) \quad \frac{E^e_{i,t}}{X_{i,t}} = \mu_i\left(\frac{AE_t}{AO_t}\right)$$

$$(3\text{-}9) \quad E_{i,t} - E_{i,t-1} = \eta_i(L)[E^e_{i,t} - E_{i,t-1}]$$

where $X_{i,t}$ = industrial demand for the i-th product at time t

$E^e_{i,t}$ = expected demand for the i-th product of Eisai at time t

$E_{i,t}$ = actual demand for the i-th product of Eisai at time t

AE_t = advertising and sales expenditure of Eisai at time t

AO_t = advertising and sales exepnditure of companies other than Eisai at time t.

From equations (3-8) and (3-9), we will obtain

$$(3\text{-}10) \qquad E_{i,t} = \mu_i \, \eta_i(L) \sum_{j=0}^{m} (1 - \eta_i(L))^j \left(\frac{AE_{t-j}}{AO_{t-j}}\right) x_{i,t-j}$$

$$+ (1 - \eta_i(L))^m \, X_{i,t-m+1} \, .$$

When $(1 - \eta i(L))^m$ is sufficiently small, the last term in equation (3-10) may be estimated as a constant. For the coefficient of the first term we may postulate that it follows the gamma distributed lags, and we use the following equation for estimation.(5)

$$(3\text{-}11) \qquad E_{i,t} = \xi_i + \sum_{j=0}^{m} \theta_i(L)\left(\frac{AE_{t-j}}{AO_{t-j}}\right) X_{i,t-j} + v_{i,t}$$

where $v_{i,t}$ is the disturbance term. In cases where there is evidence of autocorrelation, equation (3-11) is transformed in the same way as equation (3-7) to cope with this situation.

Except for nutrients, tonics, and alternatives, $E_{NU,t}$, correction for autocorrelation was necessary. In two cases, i.e., agents affecting the nervous system and sensory organs and agents for epidermis, the estimated autocorrelation coefficients were negative.

Advertising and sales activities, AE_t, would usually have spill over effects to other products of the same company. For example, an advertisement for vitamins may induce a customer to buy a drug affecting the nervous system produced by the same company. The break-down of advertising and sales expenditure into each commodity category may not explain market share as much as the over all expenditure does. In two cases, i.e., agents affecting digestive organs etc., and agents for epidermis, however, we found advertising and sales expenditure allocated for these items was a better variable to explain the Eisai products than the over all advertising and sales expenditure, judged by such things as estimated standard errors of coefficients, the coefficient of determination and the Durbin-Watson test statistic.

The over all advertising and sales expenditure, AE_t, is broken down to each product category by the distributing factor a_{it}:

$$AE_{it} = a_{it} AE_t \ .$$

This allocation factor, a_{it}, is determined by the company's sales strategy. When a new product is developed the company may make great effort to advertise and promote the new product. This point may well be demonstrated in the case of nutrients, tonics, and alternatives, $E_{NU,t}$. The company did not have well-selling products in this category until the middle of 1966 when it developed and started marketing a new product, and great efforts were made to promote it. Consequently, the equation for this product, $E_{NU,t}$, has both the over-all advertising, AE_t and that allocated for this product, $AE_{NU,t}$.

Table 3 presents the lag structures for Eisai products. Three products, i.e., agents affecting digestive organs, etc.,$E_{D,t}$, vitamin preparations, $E_{V,t}$, and nutrients, tonics and alternatives, $E_{NU,t}$, have faster reactions to the advertising and sales expenditure than other products. It may be interesting to note that these three products have been the strong point of the Eisai Company. And as such, they may well demonstrate readier acceptance by the doctors, the pharmacists and the consumers.

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(5) It may be better, if possible, to estimate the market share,$E_{i,t}/X_{i,t}$, directly rather than the output $E_{i,t}$ as is presented in equation(3-10). However, the sources of data for $E_{i,t}$ and $X_{i,t}$ are not exactly compatible since $E_{i,t}$ represents sales where $X_{i,t}$ represents production. Hence, the division, $E_{i,t}/X_{i,t}$ may generate distortion by such factors as inventory movement and delay in company's reports of production to the bureau which compiles statistics. Consequently, we resorted to the use of equation (3-10) rather than the strict market share equation.

Table 3

Lag Structure of Eisai Products

time	E_{NS}	E_{CR}	E_D	E_V	E_{NU}	E_{EP}
0	.2872	.2527	.7843	.4546	.5169	.1189
1	.2953	.2906	.1580	.2858	.2715	.2364
2	.1982	.2082	.0409	.1438	.1230	.2333
3	.1117	.1229	.0117	.0661	.0525	.1728
4	.0572	.0653	.0036	.0289	.0217	.1095
5	.0276	.0324	.0011	.0122	.0088	.0628
6	.0128	.0154	.0004	.0051	.0035	.0336
7	.0057	.0070	.0001	.0021	.0014	.0171
8	.0025	.0031	.0000	.0008	.0005	.0084

Antibiotics and chemotherapeutics, $E_{BC,t}$, and other pharmaceutical products, $E_{o,t}$, are treated exogenous to the system, since the former is a relatively new product category for the company and we do not have enough data yet to evaluate its market share behavior. Other products, $E_{o,t}$, is a relatively small fraction (0.3% to 2.5% of the total sales depending on the year) and may be treated exogenously.

3.3 The Advertising and Sales Expenditure: The advertising and sales expenditure, AE_t, is divided into two categories: (i) wages and salaries paid to the sales employees, and (ii) sales promotion expenditure.

The sales promotion expenditure, PRO_t, is formulated following[11], although we modify it to the sales maximization subject to a minimum required profit. Then, as derived in Appendix I, we will have

$$(3\text{-}12) \qquad A = k_o c' q$$

where A = promotion activities or "good will"

c' = marginal cost

q = quantity demanded

k_o = constant.

We do not have the marginal cost estimate, and hence let us represent $c'q$ by the value of sales, $V=pq$, where p is the general price level of the products. This implies that the marginal cost can be proportional to the price. Then, equation (3-12) becomes

$$(3\text{-}12)' \qquad A = k_1 V$$

where k_1 is constant.

Now, we shall treat equation (3-12)' to be a desirable situation which may not be attained instantaneously, and the current sales promotion expenditure, PRO_t, is adjusted to this situation with distributed lags:

$$(3\text{-}13) \qquad PRO_t = a_o + a_1 \xi(L) A_t + \varepsilon_t$$

or

$$PRO_t = a_o + a_1 k_1 \xi(L) V_t + \varepsilon_t$$

where ε_t is the disturbance term, and let us represent (L) by the gamma lags.(6) Table 4 below presents the estimated gamma lag coefficients:

Table 4

The Distributed Lag Structure of Sales Promotion Expenditure

Time	Lag Coefficient
0	.7269
1	.1891
2	.0568
3	.0181
4	.0060
5	.0020
6	.0007
7	.0002
8	.0001

(6) We are representing $a(=\dot{A} + \delta A)$ in Appendix I by PRO_t. The hypothesis behind the formulation of equation (3-13) is that the firm has an extremely high "decaying rate" ($\delta \simeq 1.0$). This is because the firm which has to compete in the market may fear that unless it keeps up at least with the previous advertising activities, it may not preserve the "good will" it has built up in the consumers' minds. Our observation of Japanese pharmaceutical firms supports this conclusion.

According to a consensus of the industry, the "effective price" of a new pharmaceutical product tends to be cut by 20 to 50 percent in three years, the rate of reduction depending on each product. To prevent this price reduction, a pharmaceutical firm frequently changes some characteristics of the product such as packaging design, form of dosage (e.g., tablets or capsules, or composition of ingredients of the product). and the firm sells it as a "new" product. This is a conscious effort by the firm to prevent a product from following the general trend of price decline.

In view of this, most of the price index formulae currently used in Japan and elsewhere may tend to overestimate the price reduction of pharmaceutical products, since the index formulae follow the weights given by a fixed bundle of commodities. If the characteristics of the product can be easily identified in terms of quantitative information or dummies, one may construct a price index following the works of Grilliches [7], Dhrymes [4], and Kravis [9]. However, unlike cars or refregirators, characteristics of drugs cannot be easily identified. If one tries to identify them then one is risking a distortion(or, an over- or under-estimation) of the price movement.

A solution one finds may be simple but time consuming: to change the basket of commodities frequently to cope with the changes in the characteristics of the products.(8) We constructed the price indices of Eisai products, $PE_{i,t}$, by changing the bundle of commodities for the weights whenever substantial changes in the characteristics of the commodities occurred. This method compared to a Laspeyres type price index which keeps the same bundle of commodities tended to lessen the price reduction of the pahrmaceutical products.

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(8) The Price Statistics Review Committee of the NBER,New York, presents this approach as a recommendation. See the Price Statistics of the Federal Government, NBER, New York, 1961, pp.38 - 39.

The main reason why advertising and sales expenditure, AE_t, is divided into the two categories above is that in the Japanese practice of employment, labor cost is in essence a "fixed" cost rather than a variable cost as a consequence of life-time employment and the seniority system. The practice of laying-off sales employees is uncommon in the industry. Furthermore, the Japanese pharmaceutical firms rarely use commission sales men or detail men. Sales employees are on straight salaries.

Since labor is regarded as a fixed cost, the market competition through price-cutting, rebate or discount becomes keen. Whether one will follow a straight price cut or quantity addition at a fixed price(i.e., rather than cutting the quoted price, more quantity will be added) depends upon the sales strategy. In our model discounts, $DISC_t$, are determined by the gross sales value, GS_t.(7)

3.4 Price Determination: Over the years the wholesale prices of pharmaceutical products in Japan have been decreasing, whereas the general wholesale price and especially the consumer price indices have been rising. Table 5 demonstrates this trend:

Table 5

Price Index Movement, 1967-1969
1967=100.0

Year	Output Price of Pharmaceutical Products	General Wholesale Price	General Consumer Price
1967	100.0	100.0	100.0
1968	99.3	100.2	102.5
1969	98.3	101.7	105.7

Source: Bank of Japan, Economic Statistics Annual, 1969,pp.255-258

(7) It is desirable to determine discounts by product categories. Discounts in essence are a form of sales promotion, and by breaking down into product categories, one may be able to examine in what products the firm is forced to make larger discounts. However, to break down discounts according to product categories, we need more detailed data than available now.

The prices of ethical drugs in Japan are determined by the medicare points each product can get from the Medicare Commission. Medicare points are based on equivalent products which are competing in the market. The prices of pharmaceutical products sold over the counter are influenced by the prices of their counterparts in ethical drugs and their competitors. In view of this practice, the prices of Eisai products may as well be treated exogenously. However, just as an illustration to check the mark-up hypothesis, we made the general price level of Eisai products a function of total unit cost. Once the general level is determined as a mark-up guide-line, the price of each product may be determined by the sales strategy of the company which has to take into account the strategies of its rivals.

Once the "suggested" price levels are determined, how much closer to the actual or effective price levels they may become depends on such factors as the degree of competition each product faces in the market and the popularity it commands among consumers.(9)

3.5 Wage Determination: The Japanese employment and wage system are characterized by life-time employment and uniform pay scale according to seniority, age and sex. The wage rate is determined by the average wage rate of other companies. This is because each firm attempts to keep its pay level abreast of its competitors. The employees union, on the other hand, uses the "highest rate" in the industry as the target of its salary increase demands. Thus, there exists a strong pattern setting and pattern following as far as wage determination goes.(10) We may formulate the wage rate equation as

$$(3\text{-}14) \qquad w_{s,t} = b_1 + b_2 w_{o,t} + b_3 FRS_t$$

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(9) The "effective" price level allowing for discounts resulting from price-cutting, rebate and quantity addition should be computed rather than the suggested price level which we used in our model merely for a lack of more appropriate data. Then, the effective price can be properly analyzed in its relation to sales promotion expenditure.

(10) Tsurumi, [16]

where $w_{s,t}$ = the average annual wage rate of the sales employees of Eisai at time t

$w_{o,t}$ = the average annual wage rate of pharmaceutical companies except Eisai, at time t

FRS_t = the ratio of female to the total sales employees at time t.

In the model the wage rate of sales employees, $w_{s,t}$, is treated as the basis to determine the wage rates of production employees and research employees, $w_{p,t}$, and $w_{RD,t}$, respectively. In determining the wage rate of production workers, $w_{p,t}$, the ratio of female to the total production workers, FRS_t, is used since there is a wage differential between male and female workers.

3.6 Labor Demand: The demand for sales employees, $L_{s,t}$, is made as a function of output, EX_t. It is not clear whether there exists a clear cut substitution between sales employees and capital. In some cases office machines and the increasing use of cars for sales activities may contribute to the substitution of capital for labor in the sense that the sales area per sales promoter may be widened by the use of a car. However, in the face of the rapid expansion of the company, this phenomena, if any, is hard to be put into a quantitative relationship, and the management policy on employment has not yet been too conscious of the substitution.

The production workers, $L_{p,t}$, on the other hand, will be more susceptible to the substitution of capital for labor, and for this reason the lagged relative price variable, $w_{p,t-1}/P_{k,t-1}$, is put into the equation. The estimated standard error of this variable is not significant, but the sign of the coefficient was correct, indicating the substitution of capital for labor at work. The demand for employees in research and development, $L_{RD,t}$, is determined in the model by the output, EX_t. This category of employment will be least subject to the substitution of capital for labor. And this demand is strategically determined by the firm's policy. The independent variable, EX_t, rather indicates the firm's ability to sustain the required level of R&D activity.

<u>3.7 Investment Functions</u>: Capital goods in the model are divided into two categories; machinery and equipment, ME_t, and buildings, BLD_t. Investment function follows the Jorgenson type formulation [8]. Unlike Jorgenson's Cobb-Douglas production function, however, we use a fixed coefficient production process. Investment and capital figures are taken from the balance sheet statement, and thus they suffer from usual difficulties of measuring "capital stock" such as the problem of whether the figures reflect real capital equipment in use.

It will be better to estimate net investment rather than gross investment, and this is the case in estimation of investment of machinery and equipment. However, in the case of buildings, gross investment, $GIBL_t$, is estimated. This is due to the fact that the net investment figures were derived as the difference between gross investment and depreciation allowances. Depreciation allowances are often "policy" variable in the sense that the firm can "accelerate" or "decelerate" the depreciation process within the boundary of tax laws. The net investment for construction and buildings was sometimes negative due to the fact that in some periods depreciation allowances were large compared to gross investment. Capital goods such as buildings have a long life span, and the depreciation policy, that is, the decision of when to replace an old facility may be altered or postponed depending upon business conditions, and the policy of the firm which may "window dress" depreciation to make its income statement look neat. Hence, new investment as defined above may be subject to unduly irregular factors. For this reason the gross investment of construction and buildings was estimated rather than the net investment, and in turn the latter was defined to be the difference between the former and depreciation allowances.

Investment in machinery and equipment will reflect substitution of capital for production workers, and hence, the one period-lagged production employment, L_p, is included in the equation. The estimated distributed lag coefficients for the investment functions are given in Table 6.

Table 6

The Distributed Lag Structures of Investment Functions

Time	Machinery and equipment	Building
0	.2982	.2515
1	.2962	.2904
2	.1949	.2085
3	.1083	.1233
4	.0548	.0656
5	.0262	.0326
6	.0120	.0155
7	.0050	.0071
8	.0023	.0032

3.8 Research and Development Expenditure, and Other Equations: Here we will discuss the rest of the behavioral equations in the model. Research and development expenditure, RD_t, is becoming more important in the Japanese pharmaceutical industry. One of the major reasons why the industry has grown so rapidly up to the present is that many companies have obtained licenses or know-how for manufacturing new products from foreign companies. While the licensing agreements enable the licensees to short-cut the development processes, the licensees often spend large sums of money for learning and absorbing new technologies from abroad. Upon the basis of the technologies acquired from abroad, companies often proceed to their own renovative and innovative R&D activities. This fact may be illustrated in Table 7 which presents research and development expenditure, the number of "star" products whose sales values are over 100 million yen per month, and the number of "star" products which are foreign license-based among the leading nine companies.

Except for the Eisai Company, all other companies have fairly high proportions of foreign licensed products among their "star" products. The stimulant of foreign licensing is expected to dwindle rapidly in the near future due to the changes in strategies of foreign pharmaceutical companies. With the expected 'liberalization of capital'(as it is phrased in Japan), many foreign companies are already "landing" in Japan either to open their own subsidiaries or to buy up existing Japanese firms, rather than continuing the past strategy of selling "know-how" to Japanese companies. If the Japanese companies are to survive or to compete with foreign subsidiaries, they will have to develop their own products. Consequently, the R&D expenditure may become a key factor, together with sales promotion expenditure, to determine the future of any firm in addition to the wisdom the firm must exercise in making the best of a given level of R&D expenditure and sales promotion expenditure.

Table 7

Research and Development(R&D) Expenditure and Star Products of the Top Nine Companies

Firm	R&D Expenditure, (100 million yen) (1)	R&D Expenditure/Sales Ratio (%) (2)	Star Product Selling 100 mil. yen per month (3)	Star Product under foreign license (4)	(4)/(3) x 100 (%) (5)
Takeda	37.0	5.2	27	8	29.6
Sankyo	17.5	7.7	10	2	20.0
Shionogi	15.9	7.9	11	8	72.7
Tanabe	15.5	7.8	11	4	36.3
Fujisawa	12.7	9.3	10	7	70.0
Eisai	15.1	12.2	4	0	0.0
Yamanouchi	9.0	7.7	5	3	60.0
Banyu	2.3	2.0	6	4	66.7
Daiichi	9.7	9.3	8	3	37.5

Source: Nihon Keizai Shinbun, June 26, 1969.

In the model, R&D expenditure is made a function of net sales. In the simulation, however, R&D expenditure may be treated as a policy variable and this will be explained later. At more "micro" levels than our model, one should examine the relationship between R&D expenditure and the development and marketing of a new product to determine the relationship between R&D and a new product. In particular, the marketing spill over that the new product provides for standard products of the firm will make an interesting study.

Other equations are self-explanatory: For example, interests on debts are made a **fun**ction of the level of debts. How one manages the level of debts is a matter of corporate financing, and with a proper mix of internal and external financing, one may make an effort to obtain some optimal cost of capital for the firm. If this is the case, interests on debts may be made a policy variable.

State and local taxes, TL_t, are levied on profits before taxes, but they can be claimed as a tax deductable expense in the next period. Hence, they are made a function of profits before taxes of the previous period.

Dividend payments, DIV_t, are exogenous to the model, since in the Japanese practice of dividend payments, a fixed percentage(generally 20 percent) of the par value of a common share is paid out as dividends. Hence, they are independent of the level of profits.

IV. A Simulation Exercise

The model given in Section II was solved by a modified Siedel method. First, the sample period simulation was made to check whether the model explains the actual values of the endogenous variables, and for this purpose the actual values of the endogenous variables were used. The computed values of endogenous variables were reasonably close to the actual values, judged by the Theil inequality coefficients which ranged in our case from 0.003 to 0.09. There are no well developed significant tests for the coefficients or for any other measure of sample period simulatio, and hence, the Theil inequality coefficients were used just as partial evidence of checking the workability of the model.

After the sample period simulation was done, we made a series of forecasting exercises for the four and a half years between 1970.I and 1974.I on the basis of various sets of exogenous variables.

First, we start with a basic forecast based on a set of exogenous variables given in Table 8. This basic forecast follows the assumption set I below. In Table 8 most of the key exogenous variables such as population, consumption, and medicare expenditure are based on the time trend of the period from 1959.I to 1968.II. If any reasonable forecasts of national economy are available, one may use them instead of the time trend values.

The time trend estimate of consumption expenditure, CE_t, gives an average growth rate of approximately 2.76 percent per half a year (or 5.6 percent per annum). The consumption expenditure has grown at an average rate of 4.1 percent per half a year(or 8.4 percent per annum) in the five years between October 1964 and September 1969. In view of this past performance of the Japanese economy, 2.76 percent per half a year may be a conservative estimate, if one supposes that the high growth rate of the late sixties is to be continued.

Six sets of simulation results are presented here, with each set varying in some assumptions. The assumption set I is a basic forecast. Assumption set II only differs from set I in that the industrial demand levels off in 1971.I. Starting from set III, we relax the assumption that the advertising and sales expenditure of companies other than Eisai does not react to Eisai's advertising activity. In what follows the assumptions in each set are stated and simulation results are evaluated.

<u>Assumption Set I</u>

1. Exogenous variables follow those given in Table 8.
2. The coefficient of the variable, net sales, in the R&D expenditure increases by 0.005 per period: i.e.,

$$RD_t = 0.0761(1.0 + 0.005\ i)(V_t - 0.7436\ V_{t-1}) - 31.8356 + 0.7436RD_{t-1}\ , \quad i=0,1,2,\ldots$$

3. Depreciation allowances, MED_t, and BLD_t, are accelerated from 1970.II on by doubling the solution values of MED and BLD.
4. Eisai's production of chemotherapeutics and antibiotics grows at the same rate as the industrial production.
5. Advertising and sales expenditure of other companies, AO_t, grows by 3.2 percent as given in Table 8.

The results of forecast exercise under assumption set I are presented in Tables 9 and 10. We note that the net sales value of Eisai will be doubled in seven periods from 16.92 billion yen in 1970.I to 34.64 billion yen in 1973.II. This may seem to be too rapid a growth. However, the company doubled its net sales in seven periods between 1964.I and 1968.II.(9) And the long-range plan of the firm certainly aims at this rate of growth of its sales.

Assumption Set II

1. Assumptions 1 through 5 of Set I above still hold.
2. Per capita industrial demand, x_{it}, i= NS, CR, D, V, NU, EP, BC, and o, levels off in 1971.I and stays constant for the rest of the forecasting periods.

The results are presented in Tables 11-a and 11-b. The set II was introduced since there is a certain speculation in the industry that rapid growth may soon come to an end due to expected changes in the medicare points and payment system as well as to possible anti-inflationary policies of the government. Even without the anti-inflationary measures of the government, the continued upward trend of consumer prices may force consumers to start triming their discretionary expenditure in favor of dire necessities like food, etc., and pharmaceutical products may be one of the first commodities to suffer. The set II

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(9) The growth rate of net sales largely depends upon how fast the Japanese economy will grow. For example, if we assume that consumer expenditure, CE_t, grows at an average rate of 4.10 % per half a year, which has been the actual average of the recent five years, the Eisai company will double its net sales in five fiscal periods.

is obviously quite a pessimistic case.

Assumption Set III

All the assumptions of Assumption Set I hold except for Assumption 5 of Set I. The advertising and sales activities of other companies react to those of Eisai's with one period lag:

$$(4\text{-}1) \qquad AO_t = 7.4691\ AE_{t-t} + 22125.0$$

which is a time trend estimate for the period 1959.I and 1968.II.

The result of this assumption set is presented in Table 12. The industrial demand is the same as that in Table 9. In the assumption set I we assumed that Eisai's competitors do not react to its sales activities. The firm currently ranks 6th or 7th in the industry and its market shares are not large. However, as it grows fast, it may well find more conscious reactions by its competitors to its sales strategy. The reaction function (4-1) may be too instantaneous: in actuality, other companies' reaction may have a longer distributed lag structure. Consequently, equation (4-1) may be treated as an extreme case. The results of introducing equation (4-1) are obvious: Eisai will face a slower growth and less profits.

Assumption Set IV

Same as Assumption Set III above except that the sales promotion,PRO, will grow at the rate of 15 percent per period from 1970.I.

In Set III above the reaction function (4-1) was introduced with the result that Eisai will face a slower growth. If the company is to react to capture market shares by further increasing sales promotion activities, what will be the consequence ? Assumption IV was introduced to answer this question. The results are presented in Table 13. We observe that the net sales value,V_t, return to the level of Table 10. However, the net profits will be reduced gradually.

Assumption Set V

Same as Assumption Set III except that the wage rate of the sales employees, $w_{s,t}$, which is the basic rate in the company increases 20 percent per annum from 1970 I.

The wage rate in the company has been growing fast but so far the wage rise seems to be well compensated for by the rise in productivity. In recent years, however, consumer prices are rising fast, especially in urban centers such as Tokyo. And every spring when labor unions negotiate wage increases, the unions take the price rises into account. If the wage rate is to rise 20 percent per annum, then obviously the profit levels will be affected as presented in Table 14. Compared to Table 12, the net sales values and other activities of the company seem to be unaffected.(10)

Assumption Set VI

1. Combination of Assumption Sets IV and V.
2. The cost of raw materials, RM_t, will be reduced by 15 percent in each period from 1971 I: i.e.,

$$RM_t' = .85 \times RM_t$$

where RM_t is the estimated equation (2-34)

In this forecasting exercise we combined Sets IV and V, and since the wage rise does not lead to an increase in net sales as shown in Table 14, we assumed that the firm will increase efficiency in the use of raw materials, RM_t. The results are presented in Table 15, and compared to Table 13, the

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(10) In this forecast exercise we assumed that the wage rate rise is not reflected in the increased advertising and sales promotion activities, AE_t. Recall that $AE_t = w_{s,t}L_{s,t} + PRO_t$. To make sure that the rise of $w_{s,t}$ is not reflected in AE_t, we used the wage rate equation (2-22) in computing AE_t. If the higher wage rate is to induce more productive work by the sales employees, advertising and sales activities, AE_t, may be allowed to be increased accordingly. In this case the net sales of Eisai tend to go up faster.

fall in net profits is slowed down by the reduced cost of raw materials.

The forecast exercises presented in this section may illustrate how a model such as ours may be used in short, medium or long-range corporate planning. As shown in the forecast exercises, the forecast values depend largely on what kinds of assumptions are built into the forecast. By testing the sensitivity of changes in a set of assumptions to the key target variables such as net sales, market share, profit, manpower requirement, etc., decision makers can concentrate on crucial variables for performance improvement. An exercise such as ours is not a substitution for decision makers' wisdom. Rather it is an effective aid and tool which decision makers can use to improve their understanding of the relationships among the variables. This kind of corporate model forces the decision makers to become keenly aware of the economic and social environment in which the firm is operating. By examining constantly what change is taking place in the national economy and in the industry, the decision makers can take such change into consideration when they are confronted with complex decisions.

Table 8 A Set of Exogenous Variables Used for the Forecasting Exercises; Based on Time Trend of 1959.I--1968.II

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
Population (1000 persons)									
N	103488	104006	14524	105041	105559	106077	106594	107112	107630
(0-4)	8139	8155	8172	8188	8204	8220	8237	8253	8269
(5-14)	15376	15126	14876	14627	14377	14127	13878	13628	13379
(15-34)	38781	39030	39278	39526	39774	40023	40271	40519	40767
(35-54)	26432	26674	27005	27337	27668	27999	28330	28662	28993
(55+)	14849	15021	15193	15364	15536	15707	15879	16050	16222
Consumption and medicare expenditure (billions of 1965 yen)									
CE	27076	27891	28706	29521	30336	31151	31966	32781	33596
MEDC	1192	1247	1302	1357	1412	1467	1522	1577	1632
Wage level of other companies (millions of current yen)									
w_o	.5467	.5659	.5851	.6043	.6235	.6427	.6619	.6811	.7003
Advertising and sales expenditure of other companies (millions of current yen)*									
AO	59302	61199	63158	65179	67264	69417	71638	73930	76296
Price level of capital goods (1965=100)									
P_k	110.2	111.1	112.0	112.8	113.7	114.5	115.4	116.3	117.1
Exogenous variables of Eisai products (millions of current yen)									
$\overline{E}_o$	439	461	483	504	526	547	569	591	612
ΔINPR	502	530	559	587	616	643	672	701	729
OTEX	77.4	79.6	81.9	84.2	86.5	88.8	91.1	93.4	95.7

Notes: * Assumed to grow at 3.2% per period
1) Following variables are assumed to stay constant as indicated below during the simulation period:

(Table 8 notes continued)

$P=96.17$; $P_{NU}=99.0$; $P_M= 96.2$

2) The level of debts, DET, is assumed to stay constant at DET=5244 for the simulation period

3) The dividend payments, DIV, and the renumeration to the executives, EXRM, stay constant at DIV=180; EXRM=10

4) The change in inventories of office and distribution materials, ΔINCOM stays constant at ΔINCOM=100

5) The ratio of female to the total sales employees, FRS, and that of production worker, FRP, stay constant at FRS= .2769, and FRP= .4556

6) The proportions of advertising expenditure allocated to each product category, a_{it} and the ratios to determine the individual commodity prices, ϕ_{it} stays same as those in 1968 II.

Table 9 Forecasts of Industrial Demand Based on the Set of Exogenous Variables Given in Table 8 (millions of 1965 yen)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
X_{NS}	114002	111603	129806	126626	146972	143001	165463	160457	185045
X_{CR}	63533	67236	76474	79839	90389	94121	106261	110281	143045
X_D	47053	49537	52200	55011	57932	60941	64025	67179	70398
X_V	74427	78354	82328	86400	90549	94750	98985	103246	107529
X_{NU}	76392	81222	86106	91216	96564	102121	107862	113769	119832
X_{EP}	19529	19372	19269	19209	19183	19186	19211	19254	19313
X_{BC}	87314	91687	96087	100678	105463	110414	115506	120719	126045
X_o	25880	27359	28717	29995	31245	32500	33773	35068	36385
Total	508130	526370	570987	588974	638297	657034	711086	729973	788592

Table 10 Forecasts of Eisai Activities (Assumption Set I)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
Eisai products (millions of 1965 yen)									
E_{NS}	5242	5769	6571	7255	8223	9094	10302	11404	12957
E_{CR}	3672	4017	4455	4913	5476	6076	6816	7609	8602
E_D	2642	2704	2798	2909	3051	3212	3404	3621	3880
E_V	4310	4998	5731	6486	7306	8180	9143	10192	11378
E_{NU}	2194	2510	2871	3257	3697	4182	4735	5352	6066
E_{EP}	656	770	757	827	862	925	979	1046	1117
Market shares (percentage)									
E_{NS}	4.60	5.17	5.06	5.73	5.60	6.36	6.23	7.11	7.00
E_{CR}	5.78	5.97	5.83	6.15	6.06	6.46	6.41	6.90	6.93

(Table 10 continued)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
E_D	5.61	5.46	5.36	5.29	5.27	5.27	5.32	5.39	5.51
E_V	5.79	6.38	6.96	7.51	8.07	8.63	9.24	9.87	10.58
E_{NU}	2.87	3.09	3.33	3.57	3.83	4.10	4.39	4.70	5.06
E_{EP}	3.36	3.97	3.93	4.31	4.49	4.82	5.10	5.43	5.78
Net sales, sales promotion, advertising expenditure, raw materials and profits (millions of current yen)									
V	16919	18884	20993	23027	25639	28200	31318	34636	38556
PRO	4999	5497	6061	6629	7317	8026	8857	9758	10807
AE	5702	6269	6932	7597	8394	9222	10196	11244	12487
RM	3951	4335	4811	5286	5850	6431	7137	7858	8768
ΠA	1721	1755	2076	2461	2718	3120	3599	3951	4668
Wage and employment									
w_s	.6327	.6625	.6911	.7191	.7467	.7741	.8014	.8287	.8559
L_s	1132	1193	1275	1350	1462	1568	1697	1829	1996
L_p	761	815	884	954	1038	1125	1232	1341	1480
L_{RD}	267	285	308	331	358	385	419	454	497
L	2160	2293	2467	2645	2858	3078	3348	3624	3973
Depreciation allowances (millions of 1965 yen)									
MED	216	461	491	524	558	597	638	684	732
BLD	133	289	293	295	297	300	303	306	310
Capital formation (millions of 1965 yen)									
NIME	83	85	93	99	110	118	130	138	156
GIBL	358	355	351	351	355	361	369	377	390
NKME	1379	1465	1558	1657	1767	1885	2014	2152	2308
NKBL	2599	2628	2650	2669	2690	2714	2743	2777	2820
Price level									
PE	96.4	97.6	97.6	97.1	97.3	97.1	96.8	97.0	96.0

Table 11-a Forecasts of Industrial Demand When Per Capita Demand Levels off in 1971 I and Stays Constant for the Rest of the Forecasting Period (millions of 1965 yen) (Assumption Set II)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
X_{NS}	114002	111603	129806	130448	131091	131734	132377	133020	133663
X_{CR}	63533	67236	76474	76853	77232	77611	77989	78368	78747
X_D	47053	49537	52200	52458	52717	52976	53234	53493	53751
X_V	74427	78354	82328	82736	83143	83551	83959	84367	84774
X_{NU}	76392	81222	86106	86532	86959	87386	87812	88238	88665
X_{EP}	19528	19372	19269	19364	19460	19555	19651	19746	19842
X_{BC}	87314	91687	96087	96563	97039	97515	97991	98467	98943
X_o	25880	27359	28717	28859	29001	29143	29286	29428	29570
Total	508129	526370	570987	573813	576642	579471	582299	585127	587955

Table 11-b Forecasts of Eisai Activities (Assumption Set II)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
Eisai products (millions of 1965 yen)									
E_{NS}	5241	5769	6571	7301	7898	8258	8429	8500	8506
E_{CR}	3672	4017	4455	4865	5192	5396	5485	5514	5508
E_D	2642	2704	2798	2850	2886	2870	2842	2818	2796
E_V	4310	4998	5731	6324	6784	7016	7105	7122	7114
E_{NU}	2194	2510	2871	3145	3351	3431	3446	3436	3415
E_{EP}	656	770	757	828	859	906	927	940	944
Market shares (percentage)									
E_{NS}	4.60	5.17	5.06	5.60	6.03	6.27	6.37	6.39	6.36
E_{CR}	5.78	5.97	5.83	6.33	6.72	6.95	7.03	7.04	6.99
E_D	5.61	5.46	5.36	5.43	5.47	5.42	5.34	5.27	5.20

(Table 11-b continued)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
E_V	5.79	6.38	6.96	7.64	8.16	8.40	8.46	8.44	8.39
E_{NU}	2.87	3.09	3.33	3.63	3.85	3.93	3.92	3.89	3.85
E_{EP}	3.36	3.97	3.93	4.27	4.41	4.63	4.72	4.76	4.76
Net sales, sales promotion, advertising expenditure, raw materials, and profits (millions of current yen)									
V	16919	18884	20993	22732	24295	24764	25177	25445	25697
PRO	4999	5497	6061	6569	7029	7203	7334	7449	7541
AE	5702	6269	6932	7530	8067	8260	8443	8604	8757
RM	3951	4335	4811	5214	5530	5573	5648	5702	5779
Π_A	1721	1755	2076	2383	2417	2397	2330	2324	2360
Wage and employment									
w_s	.6327	.6625	.6911	.7191	.7467	.7733	.7975	.8192	.8465
L_s	1132	1193	1275	1347	1404	1410	1420	1427	1438
L_p	761	815	884	943	988	990	999	1006	1016
L_{RD}	267	285	308	327	342	344	348	351	354
L	2160	2293	2467	2617	2734	2744	2767	2784	2808
Depreciation allowances (millions of 1965 yen)									
MED	216	461	491	523	577	586	605	617	626
BLD	133	289	292	295	297	298	298	296	292
Capital formation (millions of 1965 yen)									
NIME	83	85	93	94	86	60	37	19	9
GIBL	358	355	351	349	344	330	316	304	296
NKME	1379	1465	1558	1651	1737	1797	1834	1853	1862
NKBL	2599	2628	2650	2666	2676	2671	2653	2624	2950
Price level									
PE	96.4	97.6	97.6	97.2	97.7	98.1	98.2	98.2	98.4

Table 12 Forecasts of Eisai Activities (Assumption Set III)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
Eisai products (millions of 1965 yen)									
E_{NS}	5176	5624	6208	6621	7060	7582	8101	8674	9321
E_{CR}	3642	3937	4272	4577	4864	5212	5581	5992	6459
E_D	2600	2637	2673	2713	2707	2831	2847	2976	3042
E_V	4215	4779	5284	5729	6009	6535	6883	7406	7838
E_{NU}	2126	2392	2626	2843	2963	3289	3463	3814	4069
E_{EP}	651	576	725	769	762	780	783	800	813
Market shares (percentage)									
E_{NS}	4.54	5.04	4.78	5.23	4.80	5.30	4.90	5.41	5.04
E_{CR}	5.73	5.86	5.59	5.73	5.38	5.54	5.25	5.43	5.21
E_D	5.53	5.32	5.12	4.93	4.67	4.65	4.45	4.43	4.32
E_V	5.66	6.10	6.42	6.63	6.64	6.90	6.95	7.17	7.29
E_{NU}	2.78	2.94	3.05	3.12	3.07	3.22	3.21	3.35	3.40
E_{EP}	3.34	3.90	3.76	4.00	3.97	4.06	4.08	4.16	4.21
Net sales, sales promotion, advertising expenditure, raw materials and profits (millions of current yen)									
V	16499	18353	19920	21128	22010	23798	24961	26960	28483
PRO	4883	5341	5786	6154	6381	6833	7166	7682	8126
AE	5532	6098	6621	7063	7237	7883	8220	8900	9425
RM	3817	4218	4556	4842	4970	5421	5638	6093	6440
Π_A	1558	1702	1848	2120	2044	2379	2406	2669	2981
Wage and employment									
w_s	.6327	.6624	.6910	.7191	.7463	.7739	.8012	.8285	.8558

(Table 12 continued)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
L_s	1107	1168	1226	1277	1300	1377	1418	1499	1564
L_p	740	796	844	884	900	967	996	1063	1114
L_{RD}	260	280	296	309	316	337	347	369	386
L	2107	2244	2366	2470	2516	2681	2761	2931	3064
Depreciation allowances (millions of 1965 yen)									
MED	216	458	486	513	538	559	583	606	631
BLD	133	289	292	293	294	293	293	293	292
Capital formation (millions of 1965 yen)									
NIME	75	78	77	73	60	68	64	71	73
GIBL	354	350	342	336	327	327	325	328	330
NKME	1371	1449	1526	1599	1659	1728	1791	1863	1963
NKBL	2596	2620	2634	2640	2636	2633	2628	2627	2628
Price level									
PE	96.7	97.7	97.9	97.6	98.0	97.7	97.7	98.0	97.6

Table 13 Forecasts of Eisai Activities
(Assumption Set IV)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
Eisai products(millions of 1965 yen)									
E_{NS}	5251	5755	6475	7043	7815	8438	9274	9938	10847
E_{CR}	3676	4013	4414	4810	5269	5727	6257	6780	7392
E_D	2649	2703	2771	2852	2946	3049	3161	3278	3402
E_V	4323	4982	5619	6242	6862	7479	8093	8706	9319
E_{NU}	2207	2506	2808	3122	3450	3792	4146	4513	4891
E_{EP}	657	770	752	813	831	871	897	928	956
Market shares(percentage)									
E_{NS}	4.61	5.16	4.99	5.56	5.32	5.90	5.60	6.19	5.86
E_{CR}	5.79	5.97	5.77	6.02	5.83	6.08	5.89	6.15	5.96
E_D	5.63	5.46	5.31	5.18	5.09	5.00	4.94	4.88	4.83
E_V	5.81	6.36	6.82	7.22	7.58	7.89	8.18	8.43	8.67
E_{NU}	2.89	3.09	3.26	3.42	3.57	3.71	3.84	3.97	4.08
E_{EP}	3.37	3.98	3.90	4.23	4.33	4.54	4.67	4.82	4.95
Net sales, sales promotion, advertising expenditure, raw materials and profits(millions of current yen)									
V	16990	19005	20988	22920	25160	27347	29870	32426	35217
PRO	5012	5764	6628	7623	8766	10081	11593	13332	15332
AE	5733	6562	7508	8588	9828	11242	12859	14708	16832
RM	3989	4362	4771	5165	5602	6028	6477	6925	7437
Π_A	1805	1706	1810	1879	1877	1835	1615	1365	1199
Wage and employment									
w_s	.6327	.6650	.6911	.7199	.7467	.7744	.8014	.8288	.8559
L_s	1139	1200	1271	1341	1420	1498	1580	1661	1754

(Table 13 continued)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
L_p	766	819	877	935	999	1062	1128	1194	1270
L_{RD}	269	296	306	325	346	366	388	409	433
L	2174	2305	2454	2601	2765	2926	3096	3264	3457
Depreciation allowances(millions of 1965 yen)									
MED	216	462	492	523	554	586	618	651	683
BLD	133	289	293	295	297	298	299	301	302
Capital formation(millions of 1965 yen)									
NIME	85	86	88	89	92	92	93	92	94
GIBL	359	356	349	346	345	345	347	347	350
NKME	1381	1467	1554	1644	1735	1827	1920	2011	2105
NKBL	2600	2629	2649	2663	2674	2685	2695	2705	2716
Price level									
PE	96.3	98.1	98.7	99.2	100.2	101.0	102.1	103.5	104.4

Table 14 Forecasts of Eisai Activities
(Assumption Set V)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
Eisai products(millions of 1965 yen)									
E_{NS}	5236	5655	6240	6650	7125	7658	8196	8794	9458
E_{CR}	3669	3962	4291	4596	4899	5260	5637	6064	6542
E_D	2639	2645	2682	2723	2723	2850	2864	3001	3063
E_V	4303	4822	5316	5765	6081	6625	6979	7527	4133
E_{NU}	2190	2409	2637	2858	2995	3337	3510	3879	4133
E_{EP}	656	762	731	774	768	788	792	811	825
Market shares(percentage)									
E_{NS}	4.59	5.07	4.81	5.25	4.85	5.36	4.95	5.48	5.11
E_{CR}	5.78	5.89	5.61	5.76	5.42	5.59	5.30	5.50	5.27
E_D	5.61	5.34	5.14	4.95	4.70	4.68	4.47	4.47	4.35
E_V	5.78	6.15	6.46	6.67	6.72	6.99	7.05	7.29	7.41
E_{NU}	2.87	2.97	3.06	3.13	3.10	3.27	3.25	3.41	3.45
E_{EP}	3.36	3.94	3.79	4.03	4.00	4.11	4.12	4.21	4.27
Net sales, sales promotion, advertising expenditure, raw materials and profits(millions of current yen)									
V	16907	18500	20641	21266	22261	24243	25360	27573	29068
PRO	4997	5414	5839	6202	6462	6955	7288	7845	8286
AE	5700	6183	6708	7175	7443	8161	8552	9346	9943
RM	3948	4235	4568	4857	5011	5476	5690	6162	6493
Π_A	1514	1639	1797	2074	1959	2206	2301	2406	2705
Wage and employment									
w_s	.6481	.7099	.7777	.8519	.9326	1.0216	1.1187	1.2255	1.3424

(Table 14 continued)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
L_s	1131	1175	1230	1280	1308	1389	1428	1512	1573
L_p	761	795	835	867	877	934	950	1005	1036
L_{RD}	267	280	296	310	317	340	350	372	388
L	2159	2250	2361	2457	2502	2663	2728	2889	2997
Depreciation allowances(millions of 1965 yen)									
MED	216	461	488	515	540	562	587	610	637
BLD	133	289	292	294	294	294	294	293	293
Capital formation(millions of 1965 yen)									
NIME	83	78	76	72	62	72	67	77	77
GIBL	358	352	342	335	327	329	327	330	331
NKME	1379	1457	1533	1604	1666	1738	1805	1882	1959
NKBL	2599	2625	2638	2642	2639	2636	2633	2633	2634
Price level									
PE	96.4	98.0	98.2	97.9	98.5	98.4	98.4	99.0	98.7

Table 15 Forecasts of Eisai Activities
(Assumption Set VI)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
Eisai products(millions of 1965 yen)									
E_{NS}	5251	5755	6478	7050	7827	8455	9296	9964	10879
E_{CR}	3676	4013	4415	4813	5276	5736	6269	6796	7411
E_D	2649	2703	2772	2854	2950	3053	3166	3284	3408
E_V	4323	4982	5623	6250	6876	7497	8115	8731	9348
E_{NU}	2207	2506	2811	3126	3457	3801	4159	4527	4907
E_{EP}	657	770	752	813	832	873	899	931	958
Market shares(percentage)									
E_{NS}	4.61	5.16	4.99	5.57	5.33	5.91	5.62	6.21	5.88
E_{CR}	5.79	5.97	5.77	6.03	5.84	6.09	5.90	6.16	5.97
E_D	5.63	5.46	5.31	5.19	5.09	5.01	4.94	4.89	4.84
E_V	5.81	6.36	6.83	7.23	7.59	7.91	8.20	8.46	8.69
E_{NU}	2.89	3.09	3.26	3.43	3.58	3.72	3.86	3.98	4.10
E_{EP}	3.37	3.98	3.90	4.23	4.34	4.55	4.68	4.83	4.96
Net sales, sales promotion, advertising expenditure, raw materials and profits(millions of current yen)									
V	16998	19022	20766	22727	24998	27196	29740	32323	35172
PRO	5012	5764	6628	7623	8766	10081	11593	13332	15332
AE	5733	6562	7520	8614	9876	11316	12966	14854	17029
RM	3989	4362	4067	4398	4779	5136	5519	5899	6339
Π_A	1795	1689	2098	2119	2132	2063	1828	1546	1343
Wage and employment									
w_s	.6566	.7193	.7879	.8631	.9455	1.10357	1.1346	1.2429	1.3615
L_s	1139	1200	1273	1343	1424	1501	1583	1664	1758
L_p	765	813	867	915	970	1020	1073	1124	1184

(Table 15 continued)

	1970 I	1970 II	1971 I	1971 II	1972 I	1972 II	1973 I	1973 II	1974 I
L_{RD}	269	286	307	325	347	367	388	410	434
L	2173	2299	2447	2583	2559	2888	3044	3198	3376
Depreciation allowances(millions of 1965 yen)									
NIME	85	86	89	90	94	94	95	95	98
GIBL	359	356	349	346	346	346	347	348	350
NKME	1381	1467	1556	1646	1740	1836	1929	2024	2122
NKBL	2600	2629	2649	2663	2676	2686	2697	2706	2718
Price level									
PE	96.3	98.2	97.5	98.2	99.2	100.2	101.4	102.9	104.0

APPENDIX I

In the text we postulated the firm's goal is to maximize the value of sales subject to a minimum profit level. Under this proposition we formulate our model as follows to arrive at a relationship between the advertising activities and sales. We start with the following three assumptions:

[1] The frim can increase sales by advertising activities, A. A can be interpreted as goodwill in Nerlove and Arrow [11] sense such that

$$(a.1) \quad \dot{A} + \delta A = a \ , \text{ or } \quad g = \dot{A} + \delta A - a = 0$$

where $\dot{A} = \frac{dA}{dt}$, a, current advertising outlay and δ is the "decaying" rate of goodwill.

[2] The firm's market share function is given by

$$(a.2) \quad m = m(A, z)$$

where z is any other variable (can be a vector) which the firm does not control. The industrial demand, Q, is given by the consumer's choice:

$$(a.3) \quad Q = Q(y_d),$$

where y_d is per capita real income. Then the firm's demand q is

$$(a.4) \quad q = mQ = q(A, z_1)$$

where z_1 is again a variable exogenous to the firm.

[3] Given the cost function

$$(a.5) \quad C = C(q)$$

the profit, Π , is given by

$$\Pi = pq - C(q) - a = pq(A,z_1) - C(q) - a = R(p,A,z) - a$$

where p is the price of q. Then the minimum profit level to be maintained, Π^*, may be given by

$$\text{(a.6)} \quad \Pi^* = \int_0^\infty e^{-rt}[p \cdot q(A,z_1) - C(q) - a]dt = \int_0^\infty \Psi \, dt$$

where r is the discount rate.

Our problem is now stated that given an initial value $A(0)=A_o$, the time path of A is chosen to maximize

$$\text{(a.7)} \quad \int_0^\infty e^{-rt} p \cdot q(A,z_1)dt = \int_0^\infty \Phi \, dt$$

subject to the constraints (a.1) and (a.6).

Then as given by Theorem 1 on p.43 and Theorem 2 on p.46 of [5], there exists a constant μ and a function $\lambda(t)$ such that

$$\int_0^\infty [\Phi - \mu\Psi - \lambda(t)g \,]dt = \int_0^\infty F \, dt$$

satisfies the differential equations

$$\text{(a.8)} \quad F_A - \frac{d}{dt} F_{\dot{A}} = 0$$

$$\text{(a.9)} \quad F_a - \frac{d}{dt} F_{\dot{a}} = 0$$

$$\text{(a.10)} \quad F_p - \frac{d}{dt} F_{\dot{p}} = 0.$$

Equations (a.8), (a.9) and (a.10) become

$$\text{(a.11)} \quad F_A - \frac{d}{dt} F_{\dot{A}} = e^{-rt} p \frac{\partial q}{\partial A} - \mu e^{-rt}\left(p - \frac{\partial C}{\partial q}\right)\frac{\partial q}{\partial A}$$

$$- \lambda(t) - \frac{d}{dt}\lambda(t) = 0$$